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Supplier Prioritization to Manage Logistics Risk Factors using AHP Tool: An Empirical Case Analysis

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Abstract

Risk management in logistics is arduous and involves a recondite number of issues such as selecting suppliers, performance of the suppliers, third party, outsourcing and so on. Selecting the best supplier by abating other suppliers has always been a challenge for the production system as there many internal and external vulnerabilities with less analogy. This study assesses the operational risk factors with its plethora of tortuous and downstream partners and develops a model using Analytical Hierarchy Process (AHP) tool. Considering the selection criteria for managing risks, this tool saturates and prioritizes the suppliers. AHP engenders a practical Multi-Criteria Decision Making (MCDM) tool providing the foundation of making a documented decision making. The purpose of this paper is serving a prioritized list of alternative suppliers in a way that if one supplier is unable to sustain and supply materials, the company gets the second option to choose another supplier within no time. Thus, the production system will not be hampered, the risk factors will be minimized and the company will be beneficent.

***Keywords:** Supply Chain, Risk Management, Industrial Management*

INTRODUCTION

Supplier selection plays an important role to keep the industrial environment effective and successful in this competitive era. Nowadays, in supply chain management, the most popular studied area is strategic sourcing. That is why many researches have been done to find the best way of keeping a smooth outsourcing in supply chain management. Outsourcing means buying materials and other components from external suppliers. If these suppliers will not be selected properly, it can cause for the degradation of organization's performance. To achieve good quality products with low cost an organization must select an appropriate supplier. Product quality, lower cost, less lead time; thesse are the common factors used by an organization while selecting a supplier. But recent studies prove that these factors are not sufficient and uncertainity must be considered in selecting vendors. Establishing a trust worthy relation with one vendor is also an advanced way to minimize the risk of supplier selection.

In today's business the need of supplier risk management is huge because it helps to predict the variables which may affect the supply chain of an industry negatively. Logistics risk management is not a new concept; however, the type of risk that can affect the supply chain and the way in which these risks are managed and

mitigated has evolved significantly. Risk management basically work to develop the proactive strategies for better business.

Risk will always be inherent in the logistic system of a company. The risk is a sore reality in manufacturing today and even the most sophisticated companies used to face the different types of risk. There are many types of risk in logistics risk management such as disruption risk, operational risk, disaster emergency, service risk etc. Disruption means an unwanted incident that hampers smooth flows of raw materials and components within a supply chain. Operational risk means doubts in different factors of logistics like market demand, market price and shipping time. When problems arise in third party logistics then it can be classified as service risk. Natural calamities sometimes hamper the transportation or shipping process of suppliers which called disaster emergency in logistics risk management.

Previous research focused on logistic risk management and vendor selection respectively, however, the research of vendor selection based on logistics risk management is very little. For this reason, the decision makers of a company must consider multiple criteria in selecting the best supplier. They also should emphasize not only the traditional factors but also the risk factors. So, a logical and mathematical model for selecting suppliers can be very convenient and useful to the manufacturing industry.

The paper resembles the work on logistics risk management in Epyllion Group. This paper presents an analysis using AHP models and approach to providing a better way of decision making on prioritizing the suppliers that will dictate which supplier should be selected first and also will find the best alternative supplier for that raw material to meet the uncertainties. The factors which are important while any accident happens to the first supplier like responsiveness, keeping a promise, technology etc. are taken into account in modeling the problem. The result shows that the prioritization of suppliers varies with the variations in the considered situation. The outcome of those models will represent a distinct numerical ranking value for each of the suppliers. As avoiding risk factors is quite complex, hopefully, this modeling approach will be an outstanding helping hand to face the uncertainties.

LITERATURE REVIEW

Supplier selection (SS) has considered so important for its significant effect toward successful Logistic and supply chain management (LSCM). One of the key problems in SCM is find the best supplier among several alternatives according to various criteria, such as cost, service, risk and others. This is a complicated multi-criteria decision-making problem [1]. The most difficult job for making the logistic system smooth is to face and overcome the uncertainties. Therefore, it is necessary to develop a more effective method for supplier selection, which should be able to handle various types of uncertainties [2]. That is why researchers developed many different methodologies to examine the trend of uncertain supplier selection. Different types of tool like Fuzzy logic, Artificial Neural Network, Genetic Algorithm, PROMETHEE, DEMATEL etc. used for dealing with the imbedded uncertainty. In this paper, we used Analytic Hierarchy Process (AHP) to determine the best supplier. Ho, Xu, and Dey (2010) analyzed multi criteria decision making (MCDM) approaches for SS based on journal articles from 2000 to 2008 [3]. A web based AHP system was developed by Akarte et al. [4] for evaluating suppliers of the casting based

on 18 criteria where supplier need to register and. input their casting specifications. In the system, buyer determine the importance of the criteria based on specifications while assigning performance rating for each criteria by pairwise comparison. Muralidharan et al. [5] proposed a five-step AHP-based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria. Different departments like purchase, stores, and quality control were engaged in the selection process. A process for supplier selection to make use of the structure in analytic hierarchy process (AHP) model was suggested by Yeuh and ru-jen. It employed consistent fuzzy preference relations (CFPR) to construct the decision matrices [6]. Pema and Ruben input weights to TOPSIS method by calculating weights for each criteria based on AHP to rank suppliers. It was illustrated by a numerical example and according to results rank of supplier is determined [7]. Fuzzy analytic hierarchy process and AHP based methodology is used to select the best supplier providing the most customer satisfaction for the criteria determined [8,9]. Nilay Yücenur et al. proposed a model for selecting of the global supplier by analytical hierarchy process (AHP) and suggested AHP can be a good tool for solving multiple-criteria decision-making problem [10 Mendoza, A. and Ventura, J.A., also used AHP to rank and reduce the number of supplier [11]. Vahdani et al. (2008) demonstrated 3-Step methodology by balancing and ranking methods for supplier assessment [12]. A framework was demonstrated by Govindan, Kannan, and Haq (2010) to find out and rank the criteria and supplier performance in the automobile industry [13]. The problem associated with supplier selection in Just-in-Time (JIT) production environment was ecplored by Aksoy and Ozturk (2011) [14]. The global supplier selection problem is more complex than domestic one and it needs more critical analysis [15].

The past studies revealed that more research needs to be done to understand the importance of considering logistic risk factors during selecting suppliers. This paper presents a method which will help to find an alternative supplier quickly when the current supplier failed to perform for some uncertainties. To fulfill this purpose, Analytic Hierarchy Process methods have been used and prioritized suppliers considering suitable logistic risk factors.

COMPANY BACKGROUND

For the present study, an organization named Epyllion Group has been selected to obtain required information. This renowned company is a house of readymade garments in Bangladesh which manufacturing Knit Apparels since 1994 and have become a large company with different establishment like textile, wet processing and garments accessories. It has customers from Eurpoe, USA, Asia & Africa and work with many popular apperal brands.

Supply Chain Department of Epyllion Group is one of the most vital functional departments of the Company which deals with the Export-Import-Warehousing-Distribution activities. This department maintains good relation with all the suppliers to ensure that the production runs without any interruption. The main role of this department is achieving the best prices for the fabric, yarn, machinery & accessories that purchase as well as ensuring smooth warehousing and distribution for the customer which will bring an enormous amount of cost savings for the company. Fig 1 presents the whole distribution process of raw materials from the supplier and final product to the customer.

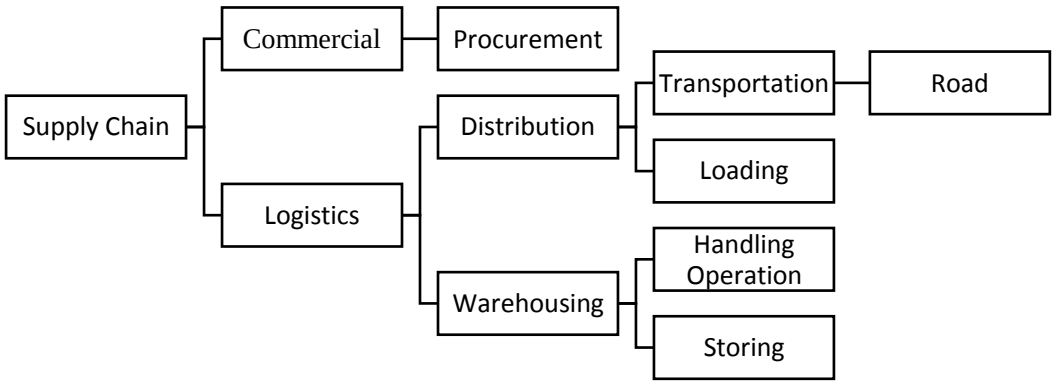

Fig: 1. *Hierarchy of supplier chain department*

PROBLEM STATEMENT

A supplier selection is a principal part of the order processing element of the entire order fulfillment process. Traditional factors to select suppliers are cost, quality, and responsiveness. But these are not only important factors that affect the overall performance but also some others factors. Some special factors have to be considered to overcome risks. Those are: Technology, Price, Service, Keeps Promise, Standardization, Packaging and Transportation cost. Suppliers must be prioritized on each of these factors because they all affect the total profitability and effective functioning of the industry.

Epyllion Company is one of the leading garments industry offering customers a high quality and versatile items of garments from a single source. With global expertise in express, air and ocean freight, overland transport and contract logistics, this company combines worldwide coverage with an in-depth understanding local markets. Company's international network links with more than 12 countries throughout the world. Epyllion garments work with over 10,000 dedicated employees, guarantees fast and reliable services aimed at exceeding customers' expectations.

Epyllion garments Industries in Bangladesh produces various types of garments like a t-shirt, pant, jacket etc. The company has many suppliers in different countries of the world to ensure its smooth production. Here, jacket which is made of 20 types of raw materials has been taken as an example for further study. Among all the raw materials are only thread, lining, seam tape, buttons, snaps, and zippers are generally purchased from outside suppliers. Specifically, for zippers a multiple number of suppliers are available. The suppliers are situated in different countries such as Singapore, Sri Lanka, Malaysia, and Japan. To identify the best supplier among them is very challenging. Suppose best supplier has been selected by using various mathematical models. But if any uncertainties like fire explosion, earthquake, strikes etc. will occur in supplier's place what will happen. So, we have formulated the following general research questions for the study:

1. What will happen if the best supplier becomes unavailable?
2. Does the second supplier of the prioritizing list suitable in that circumstance?

METHODOLOGY

Risk management process

Supplier selection is one kind of decision making process where multiple factors need to be considered [16]. The first step is identification of quantitative and

qualitative selection criteria to select the best supplier. For this purpose, AHP is a useful tool because it considers multiple criteria which are really vital for supplier selection. However, its limitations are that it only works on matrices that are all of the same mathematical forms and becomes complex with increasing numbers of criteria and alternatives. The main objective of this paper is to develop a simple and easy supplier selection model which considers relevant criteria for managing supply risks so that anyone can use it quickly without difficulty. Nine selection criteria that have significant effects on supplier selection are identified and taken as input factors to the AHP to evaluate the supplier ranking index which is considered the output. Finally, the ranking index for a specific supplier is calculated by entering the value of all the inputs of that supplier. The supplier with the highest ranking index is given the most preferences for selection. Now the same process has to be performed again to select the best alternative supplier. But this time selection criterion will be changed with consideration of crucial risk factors. Also, the weight of criteria will be changed if same criteria have been considered.

Fig. 2 shows the steps followed to develop the present model. The modeling approach is organized to deal with the company's logistics risks and then utilize the AHP tool to determine the best supplier and also best alternative supplier when necessary.

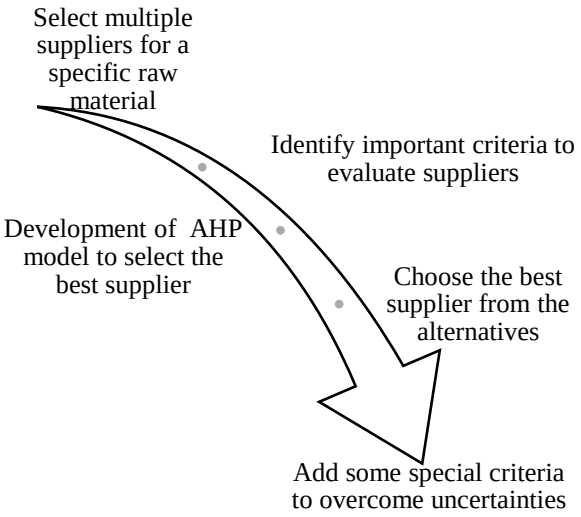

Fig: 2. *Risk Management Methodology*

Types of risks in studied networks

Risks of the companies are related to their objectives. The main objective of the owners is usually that the company should be profit-making.

In this study, we considered 11 types of risk factors. Among them, nine factors were used to get the best supplier. Factors are Quality, Delivery, Technology, Price, Service, Keeps Promise, Standardization, and Packaging. Others factors such as Demand flexibility, Adequacy of transportation, Supplier's lead time, Technological change are considered to select a best alternative supplier. These factors are important when selected supplier suddenly become unavailable. When we get to know that our main supplier cannot deliver a product that time main concern becomes to get the raw material somewhere else. The company starts looking for the alternative supplier who can give delivery quickly. If any supplier shows more flexibility to produce the large amount, can produce quickly and have a strong communication system that supplier becomes the desirable supplier for

the company. Fig 3 and fig 4 shows the factors that have been considered to select suppliers.

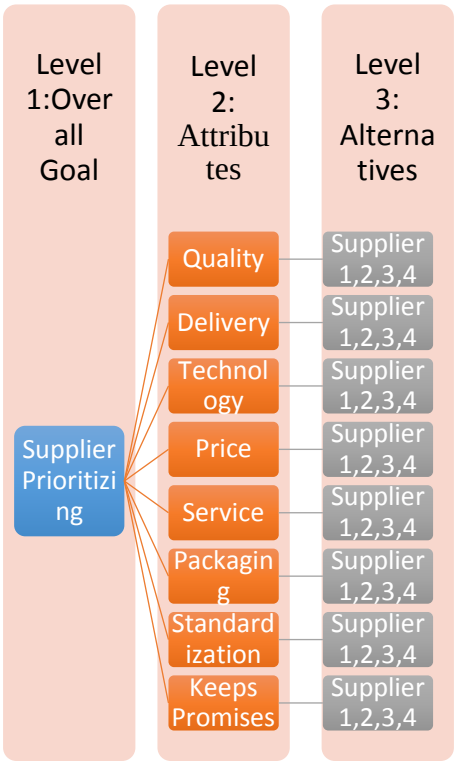

Fig: 3. *A hierarchy for supplier selection*

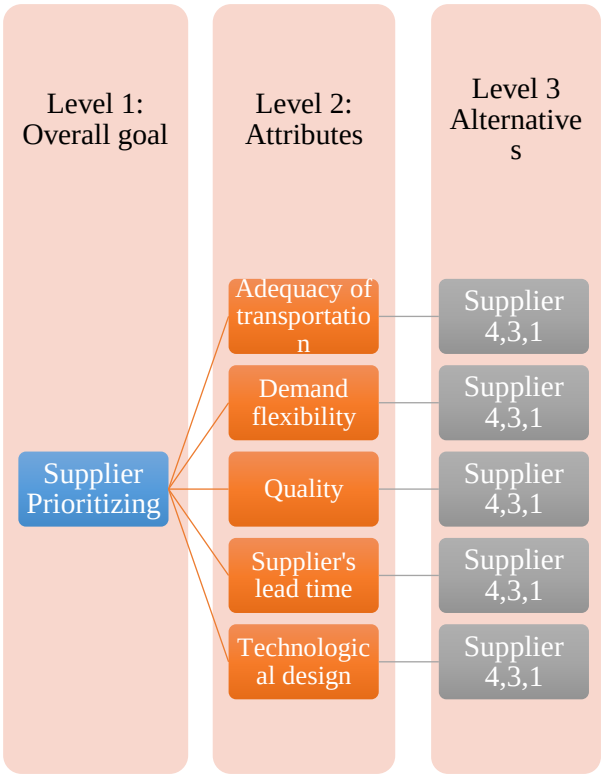

Fig: 4. *A hierarchy for selecting alternative supplier*

Considering Singapore supplier is "Supplier1", Sri Lanka supplier is "supplier2", Malaysia supplier as "Supplier3, Japan supplier as "Supplier4"

AHP methodology for research work

Step 1: Determining decision hierarchy with Attributes (criteria) and Alternatives (suppliers) where clearly shown their relationship. (Figure 3 & 4)

Step 2: Determining pairwise comparisons of attributes and alternatives with the help of pairwise comparison scale (Table 2). This is used to determine the relative importance of attributes and alternatives and also compared how well the options perform on the different attributes. The pairwise comparison judgment obtains from experts or specialist in the relevant area (Epyllion Company).

Step 3: Using an online software "AHP Calculator by CGI" to find out the weights, Maximum Eigen value (λ max) and C.I (Consistency Index) of attributes and alternatives. After entering the website, a page has been shown in figure2.Then put the pairwise comparison matrix number and submit it. On the next page put the value which represents the comparison between alternatives or attributes that were fixed in step 2.

Step 4: Calculate the value of C.R (Consistency Ratio) = C.I/ R.I where R.I (Randomly Generated Consistency index) is taken from Table 1.

Step 5: Follow step 4 find out all the weights, collect all and put them in excel sheet. Then normalize the weights and find out the best supplier.

Step 6: After finding the best supplier then cut off the best supplier and considering others suppliers another side add or remove some criteria which are risk-related criteria. Selecting all of this the full calculation repeated and prioritizing another best supplier which is best when any uncertainty occurs with the best supplier

APPLICATION OF AHP IN THE

CASE STUDY

AHP is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics. It is a technique for decision making where there are a limited number of choices, but where each has a number of different attributes, some or all of which may be difficult to formalize. It is especially applicable when a team is making decisions. It involves building a hierarchy (Ranking) of decision elements and then making comparisons between each possible pair in each cluster (as a matrix). This gives a weighting for each element within a cluster (or level of the hierarchy) and a consistency ratio (useful for checking the consistency of the data) [17].

An empirical study is done here in this article to find out the best suitable supplier during risk occurs and AHP is used in this case study.

Table: 1. *Randomly Generated Consistency Index for different size of matrix*

Size (n)	1	2	3	4	5	6	7	8	9	10
R.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 1 shows the Random index for different size of matrix. Matrix size starts with 1 having the R.I value of 0 and ends at 10 having the R.I value of 1.49.

Table: 2. *Pair-wise Comparison Scale for AHP Preferences*

Numerical Rating	**Verbal Judgments of Preferences**
9	Extremely preferred/important
8	Very strongly to Extremely
7	Very strongly preferred/important
6	Strongly to very strongly
5	Strongly preferred/important
4	Moderately to strongly
3	Moderately preferred/important
2	Equally to moderately
1	Equally preferred/important

Table 2 represents the verbal judgements for the rating. From the table 2, when the rating is 5, it means the AHP preference is strongly preferred. Similarly; when the rating is 9, it is extremely preferred. When the rating is 1, it is important. The concentration of the preference changes according to the numerical rating. The more the rating, the more the AHP is preferred.

Evaluation at level 1 for Attributes

Now in table 3, the 4 suppliers are prioritized which are selected to supply the raw materials based on the multi-criteria. By doing this, we will find out the best supplier amongst the four suppliers.

Table: 3. *Pairwise Comparison Matrix for Attributes*

Attributes	Quality	Delivery	Technology	Price	Service	Keeps Promise	Standardization	Packaging
Quality	1	1/2	1	1	1/2	1	1/2	1
Delivery	2	1	2	2	1	2	1	1/2
Technology	1	1/2	1	1	1	1/2	1	1
Price	1	1/2	1	1	2	1	1/2	2
Service	2	1	1	1/2	1	2	2	1
Keeps Promise	1	1/2	2	1	1/2	1	1	2

Standardization	2	1	1	2	1/2	1	1	1/2
Packaging	1	2	1	1/2	1	1/2	2	1

In table 3, the pairwise comparison matrix is shown. This table shows the relation matrix between each attribute with other attributes. The numerical rating was done by the group of experts by the case company. The relation between delivery to quality is 2 whereas the relation between quality to delivery is ½. Same procedure goes for all the attributes in table 3. In table 4, the weight of each of the attributes were calculated by using CGI software by putting the number of attributes and values from the pairwise comparison matrix in table 3. Consistency Index and Eigen value are also achieved from the CGI software. Then the consistency ratio is calculated which is the ratio of consistency index and random index. The C.R value must have to be less than 10%. In our study the C.R value is .075 or 7.5%, which is within limits.

Table: 4. *Weights and C.I. for Attributes*

Attributes	Weights
Quality	0.0899678
Delivery	0.157298
Technology	0.0982985
Price	0.130005
Service	0.145443
Keeps Promise	0.123368
Standardization	0.123637
Packaging	0.131982

Maximum Eigen Value =8.74547
C.I. =0.106496
n=8
R.I. = 1.41 (From 4.1)
C.R. = C.I. / R.I. = 0.0755 < 10% so, acceptable

Then the pairwise comparison matrix is done between the suppliers in table 5. The rank evaluation was done by the expert team of the company according to the basis of attributes.

Table: 5. *Pairwise Comparison Matrix for Quality*

Alternatives	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Supplier 1	1	2	1	1/2
Supplier 2	1/2	1	1/2	1
Supplier 3	1	2	1	1/2
Supplier 4	2	1	2	1

Table 6 shows the weight of the supplier alternative according to quality. The weight is measured by using the CGI software.

Table: 6. *Weights and C.I. for Quality*

Alternatives	Weights
Supplier 1	0.236799
Supplier 2	0.179609
Supplier 3	0.236799
Supplier 4	0.346792

Maximum Eigen Value =4.24923 C.I. =0.0830752

n=4
R.I. = 0.9
C.R. = C.I. / R.I. = 0.0923 < 10% so, acceptable
From the table 6, we get the max value of Eigen, and the consistency index. The consistency ratio here is .0923, which is an acceptable value. In table 7, we used the weights from table 4. Calculating the weights for each attribute for each supplier, we calculated the composite weight of the supplier.

Composite weight= {Σ (Attribute weight X supplier attribute weight)}/ Number of attributes (n)

Table: 7. *Final Evaluation*

Alternatives	Attributes and their weight								Composite Weights	Overall Ranking
	Quality	Delivery	Technology	Price	Service	Keeps Promise	Standardization	Packaging		
	0.089967	0.157298	0.0982985	0.130005	0.145443	0.123368	0.123637	0.131982		
Supplier 1	0.23679	0.244839	0.337351	0.155642	0.198101	0.340454	0.176826	0.237716	0.2372613	2
Supplier 2	0.1796	0.253612	0.126079	0.658856	0.570919	0.279187	0.433577	0.291966	0.363718	1
Supplier 3	0.23679	0.167183	0.263113	0.085928	0.102505	0.192019	0.194799	0.299752	0.1868794	4
Supplier 4	0.34679	0.334366	0.273457	0.099574	0.128474	0.18834	0.194799	0.170566	0.212137	3

From the above results, it is observed that "Supplier 2" Sri Lanka supplier is ranked 1 among 4 suppliers. Thus, the decision is to select supplier 2.

Evaluation at level 2 for Alternatives
When any risk occurs at Supplier 2 then the rest of 3 suppliers are available. Now we have considered some new attributes like Demand Flexibility, Adequacy of Transportation, Supplier's lead time, Technological Change to select the best supplier in this situation.

In table 8, we considered more attributes and the ranking was given by the expert team. A pairwise comparison matrix was done within the attributes.

Table: 8. *Pairwise Comparison Matrix for Attributes*

Attributes	Quality	Demand flexibility	Adequacy of transportation	Supplier's lead time	Technological change
Quality	1	1/3	1	1/3	1/3
Demand flexibility	3	1	2	1	2
Adequacy of transportation	1	1/2	1	1/2	1
Supplier's lead time	3	1	2	1	2
Technological change	3	1/2	1	1/2	1

Using CGI software, we calculated the Weights, C.I and max Eigen Value in table 9. The C.R value is less than 10%, so it is in acceptable condition.

Table: 9. *Weights and C.I. for Attributes*

Attributes	Weights
Quality	0.09591
Demand flexibility	0.295098
Adequacy of transportation	0.13815
Supplier's lead time	0.295098
Technological change	0.175744

Maximum Eigen Value =5.10243
C.I. =0.0256068
n=5, so, R.I=1.12
C.R= 0.02286 <10%, so acceptable

In table 10, a pairwise comparison matrix between the supplier is done for demand flexibility attribute.

Table: 10. *Pairwise Comparison Matrix for Demand flexibility*

Alternatives	Supplier 4	Supplier 3	Supplier 1
Supplier 4	1	2	1
Supplier 3	1/2	1	1/2
Supplier 1	1	2	1

Using CGI software, the Weights, C.I and max Eigen Value in table 11 are calculated. The C. R= 0.0034; the value is less than 10%, so it is in acceptable condition.

Table: 11. *Weights and C.I. For Demand flexibility*

Alternatives	Weights
Supplier 4	0.4
Supplier 3	0.2
Supplier 1	0.4

Maximum Eigen Value =3.045
C.I. =0.002
n=3, so, R.I=0.58
C.R= 0.0034 <10%
After considering the new alternatives, another evaluation is done in table 12. Supplier 4, supplier 3 and supplier 1 are selected and the composite weights of the supplier for the attributes are evaluated.

Table: 12. *Final Evaluation*

Alternatives	Attributes and their Weights					Composite weights	Overall ranking
	Quality 0.09591	Demand flexibility 0.295098	Adequacy of transportation 0.13815	Supplier's lead time 0.295098	Technological change 0.175744		
Supplier 4	0.6	0.4	0.547216	0.47423	0.549809	0.487753048	1
Supplier 3	0.2	0.2	0.263074	0.149373	0.0821306	0.173058907	3
Supplier 1	0.2	0.4	0.189709	0.376397	0.36806	0.339187837	2

From the above results, it is observed that "Supplier 4" means Japan supplier is ranked 1 among 3 suppliers. Thus, the decision is to select Supplier 4 when risk occurs with Supplier 2.

DISCUSSION AND CONCLUSIONS

Discussion

From results, it can be showed that rank of suppliers' changes with the importance of considered factors. Factors will not remain same in every situation. Uncertainty is a common thing which brings changes in normal situation. To deal with all these changes proactive strategies must be followed. For this reason, a company must consider the probable risk factors in their calculation before it occurs.

This study reveals that when selected supplier suddenly stops their delivery, the company cannot manage to run the production of the company smoothly. There remains no sufficient time to get another supplier immediately. To prevent this problem, proactive strategies should be taken. Company needs to find the best alternative while selecting a supplier. Thus, it will save time to get immediate supplier when selected supplier stops cooperating. Also, keeping relation with multiple suppliers helps to minimize

dependency and logistics risks. But managing the multiple suppliers is not an easy task. It can make the situation more complex like performance tracking, design collaboration, and synchronization becomes complicated.

In any company, supplier selection and prioritizing the alternative supplier is needed. When risk occurs, it is the alternative supplier who can mitigate the risk for the company. AHP is a simple method of selecting the supplier according to the supplier attributes and other factors. AHP is a suitable method for any company and alike Epyllion, other companies can also use this method for prioritizing their supplier.

Conclusion

The main objective of this paper is to develop a simple and straightforward supplier selection model by considering relevant criteria for managing logistics risks. 11 different selection criteria were used to determine the supplier ranking index. An AHP was applied to obtain aggregated optimized results based on some developed rules. Risks due to uncertainty were also incorporated in this model by considering some special criteria. When selected supplier will be unavailable for some unavoidable reasons then a best alternative can be found out in this way. Also, it can be applied in any company where a complex supply chain should be maintained and selecting the most suitable suppliers is very important.

Prioritization of the supplier is undoubtedly crucial for any company and it becomes harder when selected supplier becomes unobtainable. In Bangladesh, many companies use thumb rule and their past experiences to decide about such complex situation and the decision might be wrong that's why the company didn't achieve their profit properly. Also, it costs a lot of time, mental pressure and there is no scientific and logical method to make decisions on it. This uncertain characteristic affiliated with the prioritization of the suppliers leads to the utilization of AHP model, which facilitates the prioritization process by making it credible and accurate.

FURTHER RESEARCH

After conducting this case study, every company has risk factors. More risk factors bring more working opportunities to reduce it. There are so many methods to reduce the risks. Further research can be conducted by finding a better solution to find the supplier risk. Another way of doing research is by finding out more attributes that is important for choosing the supplier at initial stage. In our case study, we worked on 8 attributes. The number of attributes changes with the company and product demand. The paper emphasizes on AHP method. Further researches can be conducted by using Fuzzy AHP method or ANP method.

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